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Introduction CURRENT SERIAL RECORDS

From late 1964 through late 1968 raw sugar in world trade sold at exceptionally low prices, so low that sugar might have competed with feed grains as a livestock feed. Use of sugar as feed did in fact expand outside the United States, but the increase appears exceptionally small in spite of sugar's cost advantage during that period. Price relationships have changed during recent months so that significant displacement of feed grains by sugar is now unlikely. This circular discusses some of the factors that were involved in the use of sugar as feed in foreign markets at a time when sugar prices were low.

The pattern of world production and trade in sugar tends to pivot around four major consuming areas which are either preferential or protected markets. The United States controls its imports by a system of quotas allotted to many of the cane-sugar producing countries, paying more than world market prices in recent years. The United Kingdom also has a quota system, designed to benefit Commonwealth producers. The Soviet Union pays favorable prices for Cuban sugar under bilateral arrangements. The European Community (EC) is not a "preferential" market; rather, its sizable sugar industry is protected by a Common Agricultural Policy (CAP) providing for levies on imports or subsidies to exports, depending on the internal supply situation and world prices.

Sugar imported by the United States, the United Kingdom, and the Soviet Union, plus that imported by still other countries under additional bilateral arrangements, accounts for more than half the sugar entering world trade. The balance of sugar entering world trade is commonly referred to as world-market sugar. It is left to find its own price level on the world market. Compared to an average of 6.43 cents per pound (c.i.f., raw)

paid for sugar imported under the U. S. quota during January-October 1968 and 4.66 cents (f.o.b., raw) paid under the Commonwealth Sugar Agreement, the price of world-market sugar averaged 1.86 cents (f.o.b., raw). It has fluctuated still lower over long periods since world-market sugar prices plummeted in late 1964. Starting in September, 1968, prices changed dramatically from 1.37 cents per pound to 3.65 cents on March 11, 1969.

At such low prices, world-market sugar was a cheaper source of feed energy in livestock rations than feed grains (corn) moving in world trade. World corn prices sagged during 1968, and world-market sugar prices started to rise in late 1968 in anticipation of the International Sugar Agreement. World-market sugar as feed became more costly than corn on the world market. However, it is noteworthy that for roughly 3 years, commencing in late 1964, world-market sugar could have competed effectively with corn and other feed grains on the world market.

The actual use of sugar in livestock rations did increase, presumably displacing feed grains, but the quantities involved appear quite small in light of the cost-saving that was possible. Resisting any trend in this direction, the United Kingdom, and the EC countries, both substantial feed grain importers with sizable feed mixing industries, would be concerned in protecting their domestic grain and sugar industries. However, sugar imported for livestock feed can easily be denatured so as to prevent impact on domestic crops.

Demand for sugar as feed has been low, however. Based on available information, it is reasonable to attribute this lack of demand to the belief that low world-market sugar prices were transitory, discouraging efforts to adjust feed mixing practices and to overcome resistance to such feeds by livestock producers.

Displacement of feed grain imports by world-market sugar at present is discouraged by (1) the relatively low prices of corn on the world market and (2) the International Sugar Agreement, which provides world-market sugar with a floor price of 3.25 cents per pound. For sugar at that price to compete with corn in feed, corn would have to be priced in excess of \$2.00 a bushel.

It is not likely that world-market sugar will compete with corn on the world market. However, it can be expected that sugar will be fed to livestock to the extent that unexportable surpluses are generated in sugar-producing areas having feed-mixing industries, notably in the EC. The EC now has a surplus estimated in the range of a million tons or more; part of this will be fed to animals, affecting imports of feed grain to a minor extent.

World Production of Mixed Feeds and Demand for Sugar as Feed

Since sugar cannot be fed "straight", use of sugar as feed presupposes the existence of feed-mixing industries, and these have been expanding in many countries. World production of mixed feeds expanded by 59 percent between 1957-59 and 1965, the last year for which data are available. As shown

Table 1, there was only moderate growth in the United States and the United Kingdom. The largest quantitative increase occurred in the EC which is the second largest feed-mixing center outside the United States. Japan, Spain, and Denmark have become substantial mixed-feed producers. Much of the growth was in feed-grain deficit areas which produced 46 percent of the world's formula feeds in 1965, compared to only 30 percent 8 years earlier.

Table 1. -- Mixed feed production in major consuming areas, average 1957-59 and yearly 1963-65; in million metric tons 1/

	: Average : : 1957-59 :	1963	: 1964 :	1965 <u>2/</u>
Canada	2.6	3.2	4.8	5.3
United States	44.7	52.0	50.7	53.1
EC	10.0	16.5	18.7	21.3
Denmark	1.0	1.8	3.1	3.3
Spain2	2.7	2.8	3.0
United Kingdom	7.4	9.4	9.4	9.9
Japan	1.0	5.4	6.6	7.5
Others	4.3	7.3	8.3	9.9
Total	71.2	98.3	104.4	113.3

1/ Complete feeds, including grain and concentrate components.

2/ Preliminary.

Source: Grain and Feed Division, FAS (Circular FG 10-67, December 1967).

Larger mixed feed production is prompted by increasing demand for livestock products, advancing feeding technology, and improvements in livestock management and marketing practices. Improved techniques also extend to the feed-mixing industry itself. Sophisticated techniques such as linear programming are increasingly used in the EC (notably in the Netherlands) to determine which rations would be of lowest cost.

The poultry industry is making notable strides in a number of underdeveloped countries, implying the local compounding of rations on a growing scale. Poultry production fits well into these economies; corn prices (imported and domestic) tend to be high, while many of them are sugar-producing countries. Corn sugar competition in these countries has been insignificant, largely because of lack of knowledge of sugar as feed.

The United States imports small amounts of quota-exempt sugar for feed; these imports have trended upward in recent years, reaching 45,000 short tons in 1967. The main use of this sugar is to improve the palatability of rations for young stock, a special market.

The greatest consumption of sugar by livestock is in West Germany, where it increased from zero in 1963 to over 300,000 short tons in 1967 and accounted for about 1 percent of total feeds (grains plus concentrates). Yet this was less than half of what could have been used if locally accepted feeding levels had been applied. Much of the sugar fed was imported for this purpose from Eastern Europe. It is expected that the same level will be maintained in the 1968-69 crop year by imports from within the European Community, mainly from France.

In the Netherlands an estimated 82,000 tons of sugar went into livestock rations in 1967-68. France, Belgium, and the United Kingdom have also fed livestock appreciable quantities of sugar for several years. Spain's imports of sugar for livestock feed, roughly 11,000 short tons in 1967, increased to over 30,000 tons during January-September 1968. Total world consumption of sugar by livestock was estimated at 385,000 short tons in 1965 by the International Sugar Council. This use doubtless grew by late 1968, but additional data is unavailable.

In light of the size of the world's feed mixing industry and its rate of growth, as well as recognizable incentives to cut costs and among grain-deficit countries to conserve foreign exchange, the amounts of raw sugar used in mixed feed were unexpectedly small, considering that it was cheap and quite suitable as a feed ingredient.

Suitability of Sugar in Livestock Rations

The present discussion is confined to centrifugal raw sugar and excludes sucrose consumed by animals in molasses, raw beets, or beet pulp.

Sugar contributes only calories to the animal diet, and it is assumed that suitable adjustments would be made to provide the additional nutrients (protein, vitamins, etc.) needed in a balanced ration.

Little research appears to have been done on sugar as a source of calories in livestock rations, which is understandable considering that sugar was cheap enough to merit attention as feed for only a few years; also, in the United States world sugar has never been cheaper than corn as feed except possibly for brief periods.

Only two conclusive studies in this connection have been located. Louisiana State University researchers analyzed the effect of feeding six lots of hogs balanced rations in which raw sugar varied from zero percent to 50 percent of total digestible nutrients. ^{1/} No digestive disturbances were observed at any level of sugar feeding. At the 50-percent level, the rate of weight gain was slightly higher than at lower levels. All the hogs fed sugar were completely satisfactory as regards carcass and other physical characteristics.

1/ A. I. Mimeo Circular No. 58-2, The Effect of Various Levels of Raw Sugar in Growing Fattening Rations for Swine, 1954.

In correspondence with FAS Sugar and Tropical Products Division, Mr. E. L. Robertson, head of the LSU Animal Science Department, commented that the raw sugar mixed with the other ingredients without any difficulty; its hygroscopic character presented no problem. He added, "I believe that we have a very healthy respect now for raw sugar as livestock feed when the economic situation will permit."

Researchers at the University of Hawaii investigated raw sugar, including sugar levels in excess of 50 percent, in starter and grower rations for chickens. ^{2/} They reported. "The data . . . showed that low-grade sugar can replace cereal grains in starter and grower as well as in layer rations of chickens without physiological effect It would appear, then, that low-grade sugar can be fed effectively to young chickens at high concentrations, even to the complete exclusion of cereal grains." They also alluded to the mechanical difficulty encountered in mixing this sugar in the complete rations.

The LSU study started with the assumption that the 10-percent level would be the maximum. This coincides rather closely with the much more conservative assumptions currently held in Western Europe. It is not clear whether these conservative assumptions are based on systematic research efforts or whether they reflect subjective attitudes among livestock producers. However, available information indicates that they are held very strongly, particularly the belief that sugar, except in limited quantities, causes digestive disorders in animals.

Reports of European research efforts are lacking. However, the attitude of European livestock authorities is reflected in the following tabulation, which shows the maximum recommended level of sugar in feed as a percent of total digestive nutrients:

	<u>A</u> Percent	<u>B</u> Percent
Calf feed supplement	10	--
Sow feed	10	10-20
Pig starter	10	10-20
Hog fattener	15	5-8
Hog feed (supplement with grain)	20	--
Chicken starter	5	--
Chicken feed (2-8 weeks)	10	--
Pullet mash (over 8 weeks) ...	10	--
Laying-breeding mash	10	--
Broiler mash	10	--

Column A--From standards of German Agricultural Society (DLG), followed by virtually all feed companies in West Germany.

Column B--International Sugar Council CSC 9671. (Note by M.H. French, FAO, February 13, 1967).

^{2/} An Evaluation of Low-Grade Sugar in Starter and Grower Rations of Chickens, A. Palafox and M. Rosenberg, Univ. Hawaii, Poultry Science, Vol.33, No. 1, Jan. 1954.

It will be noted that the recommended levels for swine and poultry are much lower than those arrived at by either LSU or the University of Hawaii. Except for calves, the above makes no reference to cattle feeding. However, a Belgian authority recommends from 1 to 4 kilograms a day for slaughter cattle. He adds that nonruminants make the best use of sugar. This is consistent with practices in West Germany where most feed sugar is consumed by hogs and poultry, while consumption by cattle is minimal. 1/

Cost of Sugar as Feed Compared to Corn

The following analysis is based on the cost of 1,000 calories obtained from raw sugar as compared to the cost of 1,000 calories obtained from corn. Sugar is considered as providing calories only, while corn provides, in addition to calories, substantial amounts of protein (plus some other nutrients which are ignored here). In the price relationships discussed below, the price of corn is adjusted downward to allow for the value of the protein (see Appendix). The following table shows the cost of food energy derived from world-market sugar as a percent of that obtained from corn in world trade.

Table 2.--World markets: Calculation of cost of 1,000 calories derived from corn and from world-market sugar

	: Cost per pound	: Cost of 1,000 calories	:		
		derived from <u>3/</u>	:sugar as per-		
	Corn <u>1/</u> ; Sugar <u>2/</u>	Corn	: Sugar	:cent of corn	
	<u>Cents</u>	<u>Cents</u>	<u>Cents</u>	<u>Cents</u>	<u>Percent</u>
1963	2.39	8.50	1.22	5.10	418
1964	2.48	5.87	1.26	3.52	279
1965	2.54	2.12	1.30	1.27	98
1966	2.55	1.86	1.30	1.12	86
1967	2.59	1.99	1.32	1.19	90
1968:	:	:	:	:	:
Jan.	2.32	2.20	1.18	1.32	112
Feb.	2.32	2.17	1.18	1.30	110
Mar.	2.27	1.93	1.16	1.16	100
Apr.	2.18	1.83	1.11	1.10	99
May	2.20	1.98	1.12	1.19	106
June	2.16	1.78	1.10	1.07	97
July	2.14	1.71	1.09	1.03	94
Aug.	2.04	1.66	1.04	1.00	96
Sept.	2.00	1.45	1.00	87	87
Oct.	2.04	1.90	1.04	1.14	110
Nov.	2.23	2.39	1.14	1.43	125
Dec.	2.20	2.77	1.12	1.66	148

1/ U.S. monthly average, f.o.b. Gulf ports; No. 2 yellow. Source: Grain and Feed Division, FAS.

2/ Average monthly prices; f.o.b. Caribbean ports. Source: Agricultural Stabilization and Conservation Service, USDA.

3/ Corn, 51 percent of price per pound; sugar, 60 percent. See Appendix.

1/ Statement by P. Wahl, Int. Sugar Council, CSC (67) 3; Nov. 27, 1967.

It will be noted that average annual corn prices increased progressively from 1963 through 1967, and then fell to an average of 2.18 cents per pound in 1968. World sugar prices were abnormally high in 1963 and late 1964. They then fell to exceptionally low levels which continued through early 1969. From 1965 through 1967, sugar was a substantially cheaper source of feed energy than corn. Average sugar prices declined still further during January-September 1968, but the average cost of sugar, as feed, relative to corn as feed increased slightly as a result of the concurrent sag in corn prices. Sugar as feed cost as much as, or more than, corn during portions of this 9 month period.

Sugar prices started upward in October 1968 in anticipation of the International Sugar Agreement, so that sugar as feed became distinctly more costly than corn by the year's end. The Agreement provides a floor for world-market sugar prices of 3.25 cents a pound, c.i.f., which was attained in early 1969 and in March 1969 was 3.65 cents. Continuance of this price will prevent sugar from competing with corn as feed in the world market, barring an exceptional increase in corn prices.

The cost relationship between imported world-market sugar and domestic corn in the United States is much less favorable to sugar than shown in Table 2 because transportation costs would have to be added to the sugar price and subtracted from the corn price. The table, then, is useful mainly in reflecting competition between corn and sugar where both commodities are obtained on the world market.

Policy Environment

Government controls.--In all major markets sugar is stoutly surrounded by many administrative controls, especially where there is a domestic sugar industry to protect. These controls distort the picture of world-market sugar's price competitiveness as painted by relationships based on c.i.f. prices. Such controls are aimed at sugar as a commodity for human consumption, but all countries for which information is available envisage, among other things, imports and consumption by livestock under terms different than those applying to sugar for human consumption. Generally, such sugar must be denatured; that is, mixed with foreign substances that make it difficult or impossible for domestic refiners to render it fit for human consumption.

Sugar policy of the EC.--This is of particular concern since the EC is not only a major feed-mixing center, but also a major sugar producer and a large importer of feed grains; imports have averaged 10.5 million tons a year since 1964-65.

The objective of the Common Agricultural Policy (CAP) for sugar, which went into effect on July 1, 1968, is self-sufficiency. Since sugarbeet yields and sucrose content vary widely from year to year, this incurs the risk of overproduction and the emergence of surpluses. The CAP provides that sugar surpluses from domestic production will benefit from subsidies if exported, used as industrial raw materials, or fed to livestock.

The surplus during the 1968-69 year is estimated at about 1 million tons. The EC was offered an export quota of 300,000 tons under the International Sugar Agreement, leaving a large amount to be disposed of internally. It may be expected that much of it will be used to displace feed grains in mixed feed.

The EC will continue to import feed grains, but it is unlikely that any of these imports could be displaced by imports of cheaper world sugar. Not only are sugar prices too high at present, but there may well be more sugar available to livestock producers from internal surpluses than they will accept.

Other markets.--The United Kingdom, Japan, and Denmark are important feed-mixing countries, but there is little information as to duties on world-market sugar (denatured) or its competitive position as regards imported feed grains.

Imports of denatured sugar into Spain were liberalized in 1964 and are subject only to the 1-percent import duty plus a 12-percent fiscal tariff. Corn imports have been curtailed, and corn prices have risen, so that denatured sugar now sells for from 30 percent to 35 percent less than corn.

International Sugar Agreement.--This agreement came into effect in January 1969. It provides, among other things, a price range of 3.25 to 5.25 cents per pound, effective March 1, 1969. As stated earlier, the minimum has already been exceeded.

Restraints.--There were several factors favoring large-scale use of raw sugar as livestock feed during 1965-67. Although there was some trend in that direction, it attained rather small proportions, for reasons that would include the following:

1. Newness of cheap raw sugar. Sugar is not traditionally regarded as a feedstuff, so that there has been little study of it in this context.
2. Ignorance of sugar properties as a feed ingredient. To the extent that it is regarded at all as a feedstuff, it is widely and firmly believed (in Western Europe, at least) that it causes digestive disturbances except in very small quantities. There is also some thought that raw sugar is hard to use in mixed feed, that it does not mix well and that it gums up equipment.
3. Low prices viewed as transitory. Many who may have acknowledged the practicability of using sugar in feed, given low prices, would be deterred from doing so by the belief that prices would not remain low. There would be little incentive to undertake research, change feed-mixing practices or break down the resistance of livestock producers unless it were fairly certain that sugar would remain cheap for a considerable period. For similar reasons, governments would be little inclined toward adjusting regulations to facilitate import of sugar as feed.

Appendix

Calculation of cost of 1,000 calories derived from corn and from raw sugar

The cost of 1,000 calories derived from raw sugar is compared with the cost an equal number of calories obtained from corn. Raw sugar contains 1,680 calories per pound; hence, 1,000 calories cost 59.5 percent of the price of sugar per pound.

The adjustment in the price of corn to allow for the value of protein content was made with reference to the price of soybean meal. Basic data on corn and soybean meal were as follows:

Price per kilo: <u>1/</u>	<u>Corn</u> <u>Cents</u>	<u>Soybean Meal</u> <u>Cents</u>
1965 -----	5.560 -----	8.598
1966 -----	5.622 -----	9.370
1967 -----	5.710 -----	9.480
Nutrient content: <u>2/</u>	<u>Percent</u>	<u>Percent</u>
Crude protein -----	8.9 -----	45.8
Calories digestible energy, per kilo -----	3,571 -----	3,219

1/ From Grain and Feed Division and Fats and Oils Division, FAS, f.o.b. U. S. ports. 2/ From NRC Tables of Feed Composition.

This information may be put into the following equations:

Soybean meal: 0.458 crude protein + 3,219 calories = x cents per kilo
Corn: 0.089 crude protein + 3,571 calories = x cents per kilo

Substituting the prices applying to each year for x, the equations may be solved to obtain the following values for crude protein and digestible energy (in cents):

	<u>Calories</u> <u>Per thousand</u>	<u>Protein</u> <u>Per kg. cp</u>
1965 -----	1,321 -----	9,485
1966 -----	1,291 -----	11,380
1967 -----	1,313 -----	11,461

The proportion of the total cost of corn which may be attributed to its energy content, using in this case 1965 prices, is:

$$\frac{3,571 \times 1,321}{5.560} = 0.848 = 84.8 \text{ percent}$$

Extending the above, the cost of 1,000 calories from corn is:

$$\frac{0.848}{3.571} = 0.234 = 23.4 \text{ percent price of corn per kilo.}$$

Solving the above for each year gives the cost of 1,000 calories from corn as a percent of the price of corn per kilo as: 23.40 percent, 22.97 percent, and 22.97 percent in 1965, 1966, and 1967, respectively. For use in calculations this was rounded to 23 percent or 51 percent of the price of corn per pound.

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